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(54) **Method of monitoring and controlling shear strength in riveted joints**

(57) A method of monitoring and controlling the lap shear strength of the joint formed between two panels (14,16) through the use of a pierce and flare rivet (36) provides for determining correlation data between the height of the rivet head (38) with respect to the joined panels, and inspecting for such height or controlling such height during the manufacturing process.

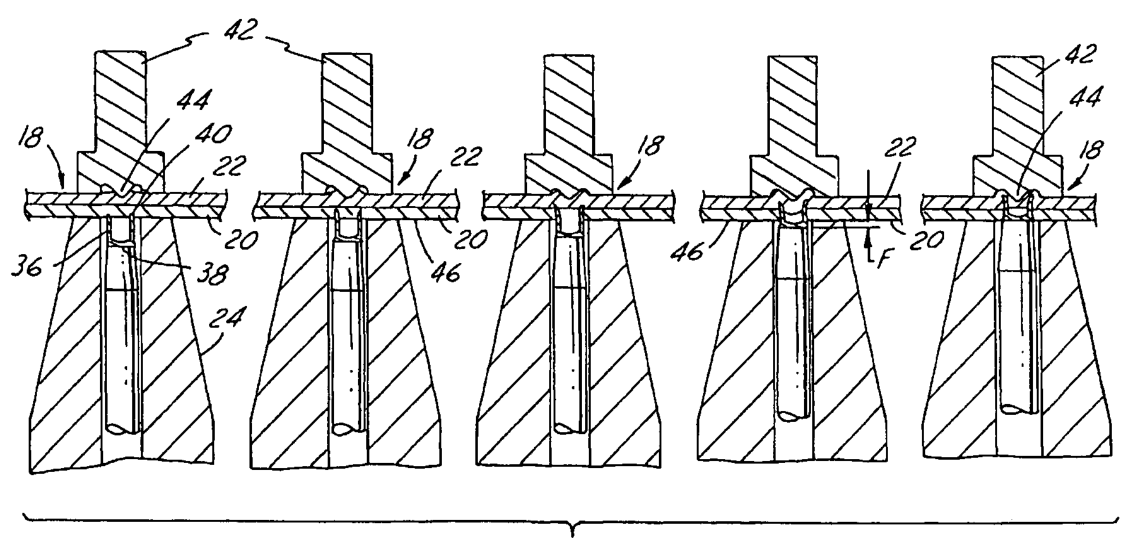

FIG.2

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Description

The invention relates generally to riveted joints, and more particularly to such joints formed by operation of pierce and flare rivets.

The challenge to the modern automotive industry to improve fuel economy in the vehicles produced has brought increased attention to the use of aluminium in body construction. To take advantage of the weight advantages of aluminium, it is necessary to employ manufacturing processes which account for the inherent difficulties in joining aluminium components which tend to add cost to the overall manufacturing cost of a vehicle.

One cost efficient technology identified for the joining of body panels is the utilisation of pierce and flare rivets to join adjacent panels in a lap joint formed by placing the panels in overlying relationship. Robotic installation of such fasteners effects cost reductions in manufacturing approaching the conventional joining methods of spot welding traditionally used in the automotive industry in the construction of steel bodies. To take advantage of the economies afforded by such a process, however, it is necessary to assure that the lap joints created possess the requisite level of shear strength for the particular vehicle design. Clearly, it is not acceptable to apply separating loads to assemble automotive vehicle bodies to assure that the joint strength is as specified. Heretofore, no non-destructive method has been known in the art.

According to the present invention, there is provided a method of monitoring and controlling the shear strength of a joint formed with two panels secured together in facing relationship by a pierce and flare rivet driven into piercing relationship with the panels from the outer surface of one of the panels. The rivet preferably has a disk-like head on the end thereof adjacent the panel outer surface. The preferred method comprises preparing a plurality of identical test joints of two test panels representative of said panels in said lap joint; piercing each of said test joints with an identical piercing flare rivet, each rivet being driven to a different control depth with respect to said corresponding test panel outer surface; measuring the shear load required to separate each said test joint; observing and recording correlation data representing the relationship between said control depths and said shear loads; choosing a desired range of shear loads; forming the lap joint; measuring the depth between said rivet head and said panel outer surface; and determining the indicated shear load of said lap joint from said correlation data.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a partial perspective view illustrating an installation apparatus for forming a lap joint between a pair of automotive body panels;

Figure 2 is a progressive cross-sectional view illustrating the installation of a pierce and flare rivet to form a joint between two panels;

Figure 3 is an enlarged view of a measurement apparatus for measuring a strength indicative dimension in a lap joint; and

Figure 4 is a graphical representative of correlation data between a control parameter and shear load in a lap joint.

Turning now to the drawings, and in particular to Figure 1 thereof, a riveting apparatus 10 is illustrated adjacent an automotive body assembly 12 for joining portions of the automotive body assembly. In the portion of the automotive body assembly 12 shown in Figure 1, an outer panel 14 and inner panel 16 are illustrated as being configured to form a lap joint, indicated generally at 18, in which an outer flange 20 and an inner flange 22 are arranged in overlying abutting relationship.

The riveting apparatus 10 is illustrated as including a positioning fixture 24 and a hydraulic ram 26 in fluid communication through connections, as indicated at 28, 30, 32, to a hydraulic power system (not shown) to drive a piston portion, indicated at 34, toward the lap joint 18. The piston portion 34 carries a pierce and flare rivet 36, as may best be seen in Figure 2, and the rivet fixture 24 includes a forming guide, to be later described, carried behind the inner flange 22. The piston portion 34 drives the rivet 36 into pierce and flare engagement with the lap joint 18, in a manner best appreciated by reference to Figure 2.

Turning now to Figure 2, the lap joint 18 is formed by driving rivet 36 into piercing relationship through the flange 20 and into the flange 22. The rivet 36 is generally of cup-shape configuration having a closed head portion 38 and an open end 40. The open end may be configured in known manner to facilitate piercing. Figure 2 illustrates the progress of the rivet 36 into the flanges 20, 22. The rivet 36 defines a central longitudinal axis, and a flare forming die 42 carried in the fixture 24 is presented in axial registration with that longitudinal axis, so that as the rivet 36 pierces the flange 20 and into the flange 22, metal flow about the central portion 44 of the die 42 effects an outward flaring of the open end 40 of the rivet 36.

Viewing the progressive piercing insertion of the rivet 36 into forming lap joint 18 shows various axial positions of the rivet 36 with respect to the outer surface 46 of the flange 20. That axial difference, labelled F in Figure 2, has been found to provide an indication of lap shear strength in a joint like in the lap joint 18. A large volume of testing has indicated that a good correlation on the order of 0.97 exists between the dimension F as a characteristic and the lap shear strength of a riveted joint.

That characteristic or dimension F can be readily measured through utilisation of the modified dial indicator 48, as indicated in Figure 3. The dial indicator 48 includes a base 50 having a die surface 52 that may be

engaged against an outer surface, such as the surface 46, then the tip 54 of the dial indicator 50 is placed against the head 38 of the installed rivet 36 to determine the measurement F.

In order to prepare for a large scale production of automotive vehicle bodies employing a variety of lap joints joined by pierce and flare rivets, it has been determined that for any given choice of materials for each of the two panels to be joined, and for any thickness of such panels, testing can be performed to determine the load required to effect shearing separation between a joint formed between such two panels by a pierce and flare rivet of a given diameter whose head, in an assembled position, is displaced from the outer surface of the panel, that is, the panel side from which the rivet is driven, a particular distance. Figure 4 illustrates data collected for a particular joint formed between two aluminium panels. Such a chart presents correlation data, and the joint designer may choose a desirable load range and determine from such correlation data the F dimension or rivet head height to be maintained and monitored in effecting formation of such a joint.

For after-assembly inspection, an apparatus like the dial indicator, shown diagramatically in Figure 3, may be used to determine the acceptability of the joint. If a depth is found to be unacceptable, of course, the operation of the ram 24 must be modified to effect piercing to the appropriate depth.

During volume manufacturing of such a joint, as that depicted in Figure 1 as joint 18, however, the correlation data may be utilised to vary the pressure of the ram and to provide mechanical axial stops for the ram 24 to control positioning of the head 38 of the rivet 36 with respect to the outer surface 46 of the flange 20.

Claims

1. A method of monitoring and controlling the shear strength of a lap joint (18) formed of two panels (14,16) secured together in overlying facing relationship by a pierce and flare rivet (36) driven into piercing relationship with the panels (14,16) from the outer surface of one of the panels and having a disk-like head (38) on the end thereof adjacent said panel outer surface; the method comprising the steps of:

    preparing a plurality of identical test joints of two test panels representative of said panels in said lap joint;
    piercing each of said test joints with an identical piercing flare rivet (36), each rivet being driven to a different control depth with respect to said corresponding test panel outer surface;
    measuring the shear load required to separate each said test joint;
    observing and recording correlation data representing the relationship between said control depths and said shear loads;
    choosing a desired range of shear loads;
    forming the lap joint (18);
    measuring the depth between said rivet head (38) and said panel outer surface; and
    determining the indicated shear load of said lap joint (18) from said correlation data.

2. A method as claimed in claim 1, wherein said indicated shear load is outside of said desired shear load range and further comprising the step of modifying said forming step to change said depth between said rivet head and said panel outer surface.

3. A method as claimed in claim 1 or 2, wherein said preparing step is conducted for a plurality of sets of identical test joints wherein each set consists of panels of certain thicknesses and materials and rivets of certain diameter.

4. A method of forming a lap joint between two panels with a pierce and flare rivet of cup-like configuration having a closed head end and an opened end; the method comprising:

    preparing a plurality of identical test joints of two test panels representative of said panels in said lap joint;
    piercing each of said test joints with identical piercing flare rivets, each rivet being driven to a different control depth with respect to said corresponding test panel outer surface;
    measuring the shear load required to separate each test joint;
    observing and recording correlation data represent the relationship between said control depths and said shear loads;
    choosing a desired range of shear loads;
    forming the lap joint;
    placing said two panels in overlying facing relationship;
    positioning a flare forming die below the lower of said panels;
    positioning said rivet in registration with said die on the upper of said panels with said rivet head end facing upwardly; and
    driving said rivet into said panels to a depth wherein the depth of said rivet head with respect to the outer surface of the upper of said panels indicates from said correlation data a lap shear strength within the ranges of said desired lap shear strength.

5. A method as claimed in claim 4, wherein said preparing step is conducted for a plurality of sets of identical test joints wherein each set consists of panels of certain thicknesses and materials and riv-

ets of certain diameter.

6. A method as claimed in Claim 4 or 5, wherein the material of one of said panels is aluminium.

7. A method as claimed in Claim 4, 5 or 6, wherein said one panel is the upper of said panels.

8. A method as claimed in Claim 4, 5 or 6, wherein said one panel is the lower of said panels.

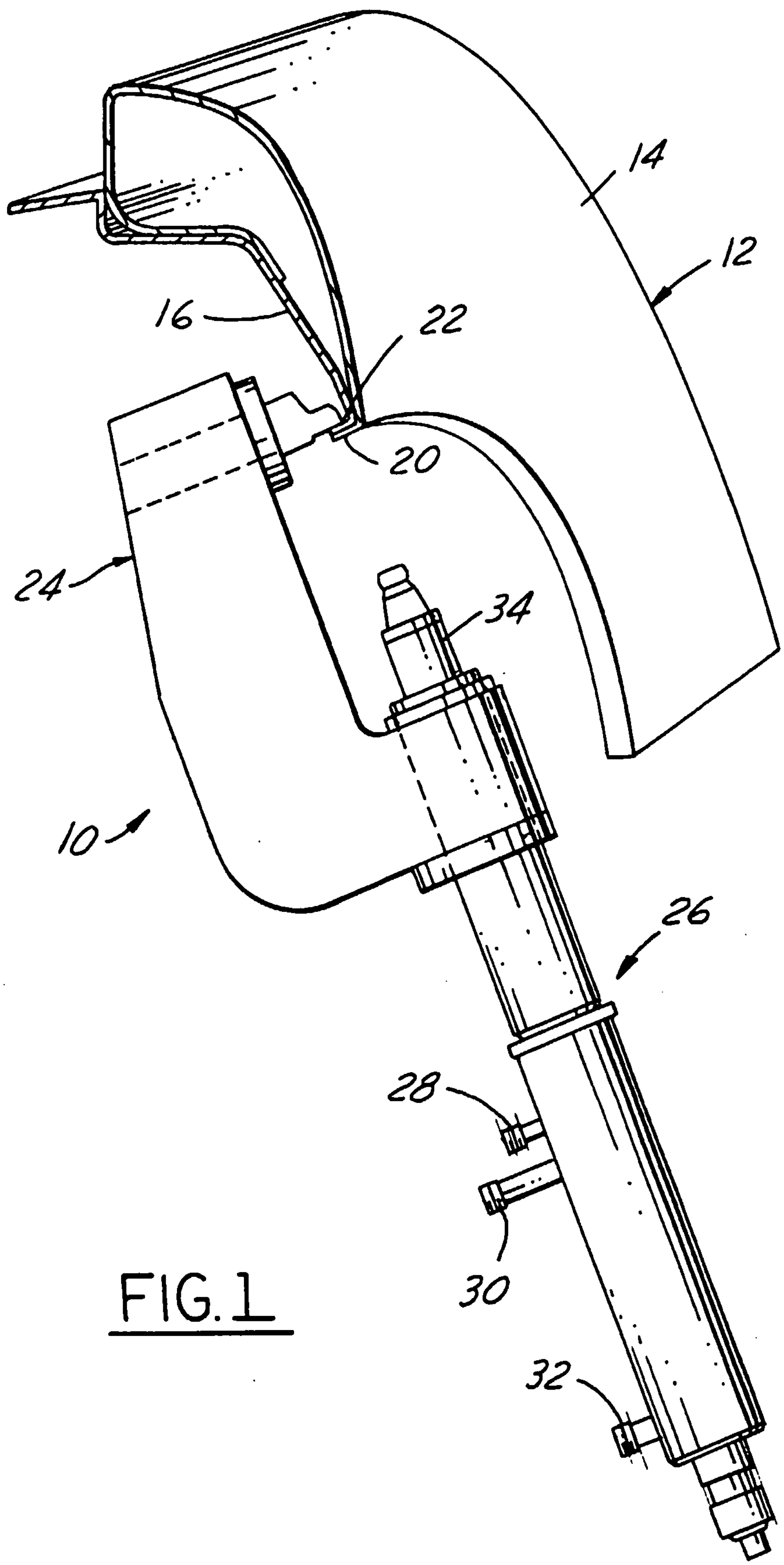

FIG.1

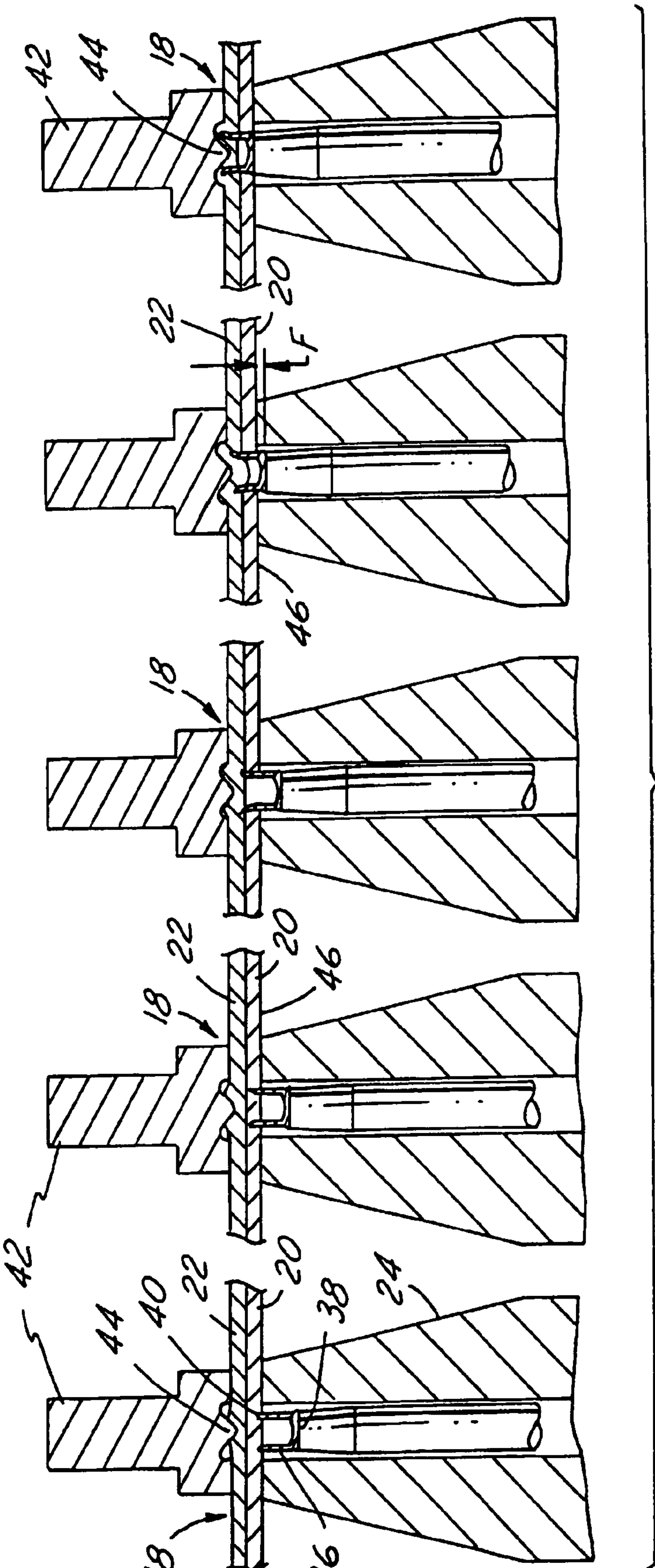

FIG.2

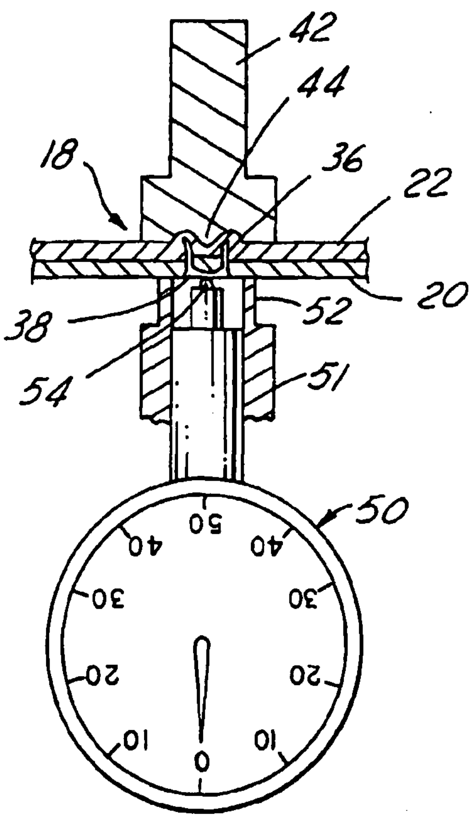
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FIG.3

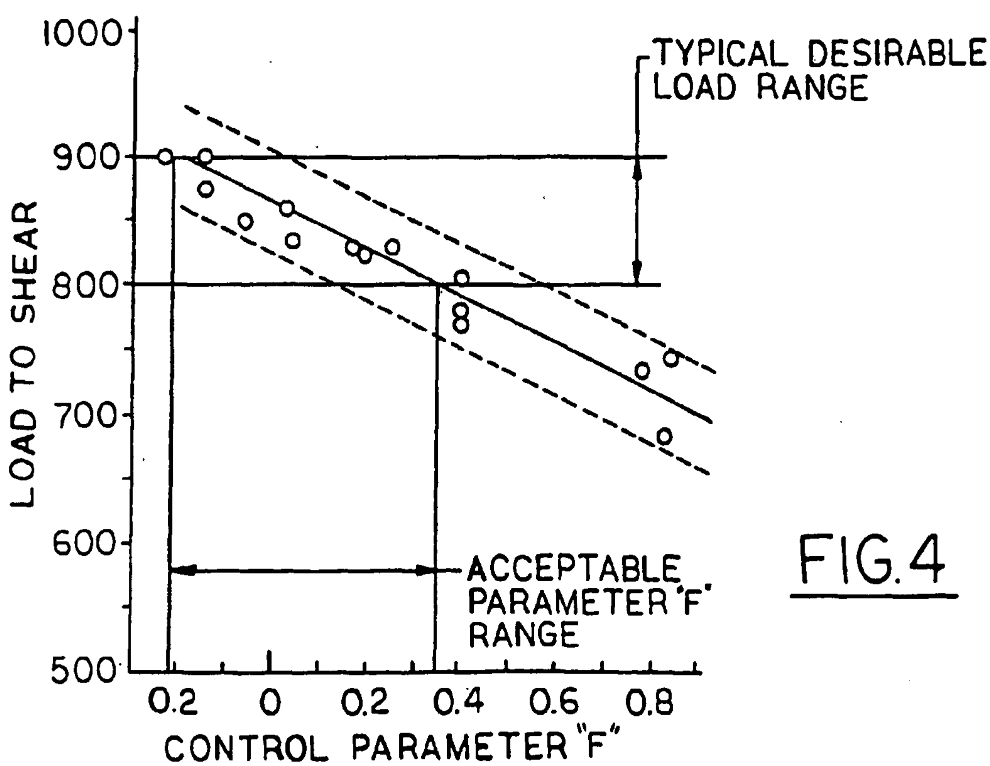
1000
900
800
700
600
500
TYPICAL DESIRABLE
LOAD RANGE
LOAD TO SHEAR
ACCEPTABLE
PARAMETER "F"
RANGE
0.2
0
0.2
0.4
0.6
0.8
CONTROL PARAMETER "F"

FIG.4